

ENGINEERING CASE LIBRARY**A MATTER OF GRAVITY**

Steve Vamos, a mechanical engineer, was faced with the problem of modifying the location of the wheels on a trailer for a back-hoe. Discussing the problem with his former design professor makes him realize that the problem could be handled with a few measurements and the analysis that he had learned in the first course in statics.

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Prepared by Professor G. Kardos of Carleton University, in Ottawa Canada, with the assistance of Steve Vamos.

A MATTER OF GRAVITY (A)

Steve Vamos knocked on the door of his design professor's office. When the door was opened he asked, "Do you have a few minutes? I'd like to talk to you about a problem I'm having."

Steve had just graduated in Mechanical Engineering from Carleton University. He hadn't yet found a permanent job but was helping a friend, a small independent contractor for whom he had worked in previous summers.

Steve explained that the contractor had a local welding shop build a 20 ton float (trailer) for carrying the back-hoe from job to job. The firm that had built the trailer was just a welding job shop and had no engineering expertise. The float looked satisfactory (Exhibits 1 and 2). It had a three-axis boggy and a tongue that would fit into the "fifth wheel" (pivot) in the back of the contractor's truck.

Although the system looked satisfactory it wasn't quite right. They found that when they tried to back up with the loaded trailer the wheels of the truck would spin. They surmised that there wasn't sufficient load on the truck to provide the necessary traction. This meant that there wasn't sufficient weight on the tongue. In order to correct this, the wheels of the trailer should be moved back. The question was how far?

Steve went on to explain: "Most such trailers are poorly designed when it comes to tongue weight. Trailer manufacturers usually recommend adding weight to the trailer if there isn't enough or to ignore it if there is too much. Too much weight could cause premature spring failure in the truck, usually these are company trucks so the operators don't care. Right?"

"But in this case the contractor is both the owner and the operator. He is concerned about getting the greatest life he can get from all of his equipment."

"In addition to the tongue weight, the contractor has a tank with 400 pounds of fuel in the back of the truck. The tongue weight must be increased to give the necessary traction. But he would like to keep the tongue weight to less than 2000 pounds."

Steve then proceeded to explain to his professor that he would like to know how to find the center of gravity of the back-hoe and the trailer - since they were of irregular shape - so that he could figure out how far to move the trailer wheels. After some discussion his professor explained that by finding the load on

the individual wheels of the tractor and the trailer it shouldn't be difficult to use elementary statics to find the information Steve was after.

During the discussion Steve said that he had access to a large scale at a local junk yard and could make the necessary measurements. There was some discussion between them about setting up the necessary equations in closed form but it was decided that they would be messy and probably not contribute much to the solution. Rather, Steve decided to go out and make what measurements he could and proceed from there.

He promised he would come back and show his results.



Exhibit 1 Back-hoe on trailer, normal position.



Exhibit 2 Back-hoe Trailer and Truck

A MATTER OF GRAVITY (B)

Steve made some sketches of the principal dimensions of the back-hoe and the trailer (Exhibits 3 and 4). Then he took the equipment to the scrap yard and measured the loads on the front and back wheels of the back-hoe, and added these to his sketch.

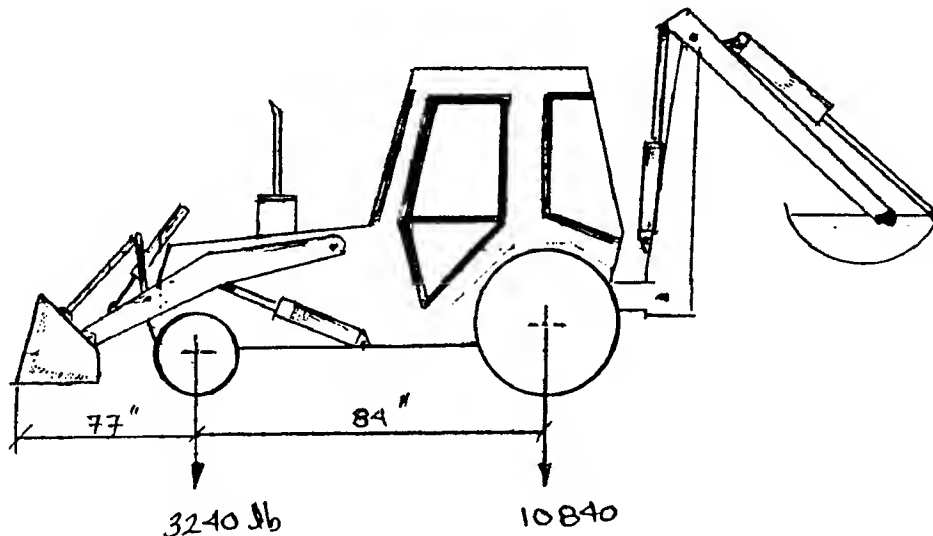


Exhibit 3 Sketch of Back-Hoe

The total weight of the trailer was 4900 pounds. The tongue weight of the trailer empty was 480 pounds, with the back-hoe on board it was 594 pounds. By curling the front bucket of the back-hoe he could move it 12 inches ahead to get a tongue weight of 1540 pounds, by moving it 18 inches ahead he got a tongue weight of 1800 lbs.

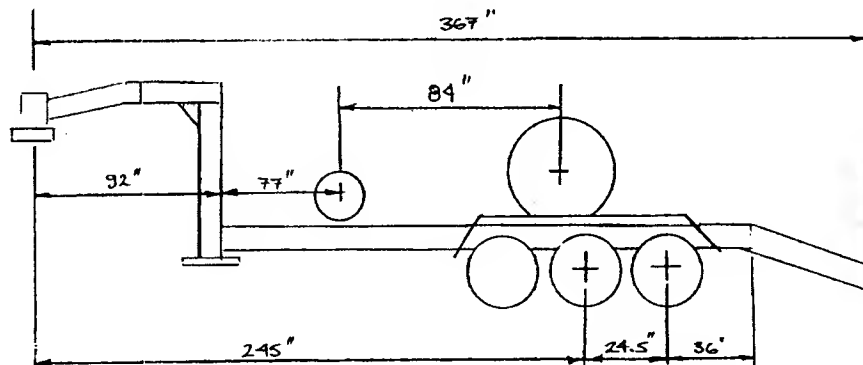


Exhibit 4 Dimensions of the Trailer

With this information Steve went ahead and made his calculations.

A MATTER OF GRAVITY

Instructors Note

This case is a practical example of the application of simple statics. Unfortunately it highlights the problem that many new graduates have. They can solve ordinary problems of the kind they learned in school, but they have not yet learned to generalize the information for unusual problems.

This problem is one of diagnosis. Steve recognized that if he had the center of gravity of the back-hoe he would be able to adjust the wheel position. But he did not recognize that the same statics could be used to find the center of gravity from the wheel loads.

The case is in three parts.

Part A can be used to ask students what measurements are required. They could be asked to prepare the necessary equations to find the minimum measurements required.

Part B gives the actual measurements made by Steve. The students could be asked to find the distance that the wheels should be moved.

Part C gives Steve's solution and the changes made in the trailer. Students could be asked to evaluate Steve's recommendation and to discuss the resultant compromise.

It should be noted that when making the measurements with the front bucket curled, a practical answer was available without the necessity of making any further calculations.

The discussion and analysis of this case should be easily conducted within a single fifty minute class period.